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MASTERY OVER PLANTS

HISTORY AND CULTIVATION OF THE TONKA BEAN (*DIPTERYX ODORATA*) WITH ANALYSES OF TRINIDAD, VENEZUELAN AND BRAZILIAN SAMPLES

NOTES ON THE CONTROL OF MANGO ANTHRACNOSE (*COLLETOTRICHUM GLOEOSPORIOIDES*)

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TROPICAL AGRICULTURE

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MASTERY OVER PLANTS*.

A chance visitor to any of the shows staged by the Royal Horticultural Society in London, or by other societies elsewhere, will not fail to marvel at the achievements of the professional horticulturist, who seems to be able almost to ignore the seasons in producing his specimens for exhibition. Much of this success is due to a newly-discovered ability to control many of the phases of plant growth and development by chemical means. In fact, substances are available which will cause a plant to wake up from a condition of dormancy, will cause it to blossom or form tubers, will make fruit ripen or delay ripening, will cause a plant to shoot out roots from its stem or, going to the other extreme, will anaesthetise the plant. This progress is due to an understanding of what may collectively be called *plant hormones*, the story of which is of sufficient interest to make its recital worth while.

The broad question is whether the process of growth in a plant depends on the constant application of a material stimulus, or is merely the consequence of the presence of the substances requisite for constructive purposes by the plant. The famous botanist Sachs conceived the idea that plants exert chemical control over their flowering and fruiting processes, but he was unable to determinine what organ produced the active chemical substance that initiated the action, nor what this substance might be. Darwin, in his study of the response of plants to light, also formed the belief that some chemical substance was involved in light response. He established the fact that the stimulus was perceived by a region near the tip of a shoot, the response, evoked further down the stem, causing unequal growth, resulting in curvature.

The scientific work on the selective permeability of plant tissues began about 1909 with the experiments carried out by Adrian Brown on the barley plant. The seeds of many varieties of barley possess a blue pigment in the layer just below the outer skin, which becomes red when acid is brought into contact with it; this change provided a means of demonstrating which substances were able to penetrate through the membrane of the corn into the interior of the grain. The experiments brought out in particular the fact that none of the substances normally produced during germination can escape from the grain through the membrane, nor can the salts normally

* Adapted from an article by E. F. A. in *The Jr. of the Royal Soc. of Arts*, Vol. LXXXV, No. 4428, pp. 1013-1016, 1937.

present in soil water enter. Only a limited number of substances can pass through, such as weak organic acids, ammonia, simple organic compounds like alcohol, ether, acetic esters and a few inorganic salts.

These observations were considerably extended by work carried out on leaves by H.E. and E.F. Armstrong, who showed that plants generally are provided with differential septa or, in simpler parlance, membranes capable of distinguishing or differentiating between substances. Water can pass through these at all times, but not soluble salts; they are penetrated by a number of organic compounds and a few inorganic salts, all of which have the property in common of exhibiting little affinity for water.

The stimulant was termed "hormone", in view of the analogy between its mode of action and that of the then newly-discovered hormones in animal physiology. Professor Starling objected to this use of the word, and it has fallen into abeyance botanically until the new discoveries have fully justified the former application of the word.

When these substances penetrate into the cell, they upset the water balance and cause conditions to arise favourable to hydrolysis or down-grade changes; in other words, the stimulus causes growth. For example, glycosides present in the leaves are hydrolysed, and the products of hydrolysis may now undergo oxidation; it is indeed by such changes that the penetration can be experimentally demonstrated; *e.g.*, laurel leaves give off prussic acid, aucuba leaves blacked at the surface. In the test-tube, these changes proceed to the end, causing death. In practice, the stimulants must only be used in proportions not exceeding a certain low maximum, since they will become toxic when this concentration is exceeded. An example is afforded by ammonia, an invaluable fertiliser when used with discretion, but harmful when applied in excess. It thus appears probable that growth is dependent on the constant application of material stimuli, and that certain fertilisers are effective because they act as stimulants.

Some twenty years later the discovery was made that a strange chemical substance, of which at first the nature was unknown and the chemical structure thought likely to be very complicated, was produced in the growing tip of the plant. It was named "auxin", and it was regarded as a hormone; the work of Professor Went and other Dutch plant physiologists has taught us much about this substance, and made possible its isolation and the subsequent identification of its chemical structure by Kögl.

Subsequently, another active growth promoting substance was isolated from urine, and from certain mould fungi. This substance is indolyl-acetic acid, which the chemist can make by synthetic methods in his laboratory; it is now often spoken of as hetero-auxin. The supply of hetero-auxin in urine is derived from food; other auxins come from fats in which they are present as esters. The action of hetero-auxin is apparently indistinguishable from that of auxin.

Now that interest has been aroused in the subject, quite a number of related synthetic compounds have been proved to have similar action in causing root development, curvature and bending of stem and swelling of stems and petioles, though the original indolyl-acetic acid is perhaps as active as any substance as yet tried. Among these newer substances, naphthalene-acetic acid has proved a suitable and more accessible material for practical use, likewise phenyl-acetic acid. It is convenient to apply the name auxin generally to substances with these properties.

The growth-promoting substances are conveniently applied by rubbing a lanolin preparation on the surface of stems or petioles, or by placing the basal ends of cuttings in a water solution.

Naturally these experiments with synthetic auxins have attracted great interest in the horticultural world, and commercial preparations (one of them called "hortomone") are already on the market. In this connection, attention may be drawn to an article by Dr. Tincker in the *Journal of the Royal Horticultural Society**. In practice, the cuttings are taken, trimmed ready for insertion in the rooting medium, bunched together, and then placed in the rooting solution to the depth of an inch over-night. They are then rinsed in water and set out in the ordinary way. The use of the synthetic auxin enables cuttings, even woody cuttings which normally strike with difficulty, to be grown with ease, and ensures stronger and more vigorous plants.

One of the most interesting horticultural advances of recent years has been the discovery that a few gases of simple chemical structure have an anaesthetic and stimulative effect on plants. They behave similarly to plant auxins, causing epinasty or bending, modifying growth and initiating roots. Outstanding in this respect is ethylene; very much less active are acetylene, propylene and carbon monoxide. Ethylene is not a tissue killer; it increases respiration in low concentrations and decreases it when present in high concentration. In proper concentration, it causes a reduction in the rate of elongation. Ethylene is very effective in hastening the colouring of citrus fruits, for which it is used commercially. Ethylene undoubtedly modifies plant metabolism, including the destruction of chlorophyll, the hastening of colouration, and the ripening process of fruits. Ethylene also possesses rhizocaline or root-forming effects. If intact plants are exposed to air containing a proper concentration of ethylene for a few days and then removed to a moist chamber free from the gas, profuse rooting results. This rooting may be general or

* December, 1936.

limited to that region of the stem which was growing at the time of exposure. Whilst the gas initiates roots, it inhibits their growth, hence the necessity of their removal to a moist, gas-free chamber.

In view of the striking behaviour of ethylene, it is interesting to note that ethylene itself is a product of plant metabolism. This possibility was first surmised for the apple fruit, the final chemical proof having been afforded by Gane. It has since transpired that by far the most delicate test for ethylene is the epinastic response of leaves, the most suitable test-plant having proved to be the young potato when it is about 4 to 8 inches high; in the presence of ethylene emanations, the leaves bend over and the plant droops. In this way ethylene has been proved to emanate from many fruits, from the flowers and leaves of dandelion and other plants, and from the young shoots or stems of asparagus. Ethylene at similar concentrations is very much more effective than the plant auxins consisting of large molecules. It acts as a hormone like the many substances described by the Armstrongs. It produces general metabolic changes, causing an increase in the amounts of soluble sugars, amino-acids and hydrolysis-products, at the expense of the insoluble carbohydrates, proteins and fats.

Only three other gases so far have been found, out of about thirty that have been tested, which act like ethylene but they are materially less active. They are propylene (the hormologue of ethylene), acetylene and carbon monoxide; all three are alike in being short chain substances and unsaturated carbon compounds.

The artificial auxins are characterised by having acetic acid attached to a hydrocarbon, but they differ greatly from ethylene.

A considerable number of simple substances have been tested at the Boyce Thompson Institute at Yonkers, New York, most of which, according to the Armstrongs, were able to penetrate the leaf membrane and induce hydrolysis. Their action was negative in causing epinasty. Among those tested were the unsaturated ring hydrocarbons, benzene, naphthalene and toluene; chloroform, ether; certain sulphur compounds; ammonia pyridine, alcohols and aldehydes. It would appear, therefore, that the hormone effect of promoting hydrolytic change, observed by the Armstrongs, and that producing epinasty, are not the same.

It is of particular interest from the point of view of structural chemistry that, whereas propylene (the hydrocarbon) is active in producing epinasty, the corresponding allyl alcohol and acrolein (an aldehyde), are inactive.

Ethylene-induced epinasty is not a universal phenomenon; out of 202 species and varieties of plants tested at Yonkers, 89 showed it and 113 did not.

In the plant there are apparently two periods to be distinguished, namely, that in which assimilation takes place under the influence of light, and that in which growth takes place at the expense of the materials previously synthesised. The latter period probably is that during which stimulation is necessary, for which some hormone may be required; it is that in which enzymes are brought into action as simplifying agents. At this moment substances which have been kept separate, either in different layers or in cell vacuoles, come together, and the products of their action enter into circulation and are carried into tissues in which they can be used as building materials in the manifestations of growth. One specific action of ethylene is to check root growth; but the impulse to form roots is still strong in the plant and roots may be produced elsewhere. These new roots cannot grow in an atmosphere of ethylene, but do so in an ethylene-free moist atmosphere.

SILICA DUST AS AN INSECTICIDE.

Many substances used as insecticides are actual insect-poisons, but various non-poisonous materials in the form of very fine dust have also been tried at different times, their lethal effect being more of a physical nature. In a series of recent trials one of the most promising of these materials was a proprietary silica dust stated to consist of a pure quartz sand, ground to such a degree of fineness that the particles approach colloidal size, and to contain 98 per cent. of silica, with only very small quantities of aluminium, iron, calcium, and magnesium compounds ("Versuche zur Bekämpfung des Kornkäfers mit Staubmitteln" by B. Germar, *Z. Angew. Ent.* 1936, 22, 603-630).

The practical trials were made with the granary weevil (*Calandra granaria*). It is believed that the fatal effect of the dust is due to a withdrawal of water from the tissues of the insect, owing to the large increase in body surface caused by the adherent dust. The effect of the dust is consequently dependent upon the fineness of the particles, and their power of adhering closely to the body of the insect, but the age of the insect is also a factor, the younger individuals being definitely more readily susceptible than the older. The temperature and the relative humidity of the atmosphere are also important.

The treated grain should contain one per cent. by weight of the dust, which is best applied in the autumn or at the end of the winter, and should, of course, be stored in a dry place. The dust is non-toxic, and is removed by the usual processes preceding milling.

The treatment is said to be effective with regard to the existing weevil population, in retarding oviposition and hence preventing reinfestation, and to be economically practicable from the point of view of cost and ease of application.—(*Bull. of the Imp. Inst.* Vol. XXXV, No. 3, p. 365, 1937.)

HISTORY AND CULTIVATION OF THE TONKA BEAN (*DIPTERYX ODORATA*) WITH ANALYSES OF TRINIDAD, VENEZUELAN AND BRAZILIAN SAMPLES.

By F. J. Pound,
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Introduction.

Several articles have been written since 1930 on the subject of Tonka beans and their cultivation. The interest in this crop in Trinidad lies in the ease with which the trees grow, the present remunerative price and the suitability of the tree as a substitute for cacao on certain of the poorer soils of the Colony. In the present paper liberal use has been made of material, for which the writer is grateful, published in the Proceedings of the Agricultural Society of Trinidad and Tobago (1), in the Agricultural Journal of British Guiana (2), and of information furnished in a memorandum prepared by Kew in 1935. In addition, reports on samples sent to the Imperial Institute for analyses have been largely reproduced *verbatim* in the last section. The writer, in particular, very gratefully acknowledges the valuable field data and other information supplied to him by Mr. R. O'Connor, Manager of River Estate, who has had very considerable experience of this crop.

The cultivation and manurial experiments described are being conducted jointly by the writer and the owners or managers of various estates in Trinidad. It is hoped that the extensive recent plantings on the Government Estate will provide uniform material for many more experiments, since the older trees in Trinidad do not lend themselves easily to experiments on account of irregularity of bearing, age and planting.

Botanical.

The bulk of the Tonka beans of commerce comes from the tree *Dipteryx odorata* (Willd) but some confusion has been caused through the use of the old name Coumarouna. It is probable that more than one species of Dipteryx provide beans for the market. For instance *Dipteryx rosea* (Spruce) and *Dipteryx punctata* (Blake) are said to contain coumarin. Other species, *D. polyphylla* Hub. and *D. oppositifolia* (Willd) are reported by Ducke to be odourless.

Dipteryx odorata is indigenous to South America where it is found in the forests of Colombia, Venezuela, the Guianas and Brazil. The largest commercial quantities of beans come from Venezuela along the tributaries of the Orinoco, particularly the Caura and Cuchivero rivers. In British Guiana it is reported prevalent on the upper reaches of the Kaituma.

The tree is described as of "usually compact habit, with dark green shiny leaves and pale greyish trunk and branches. It may reach a height of 150 feet, with a trunk three feet or more in diameter. The timber is hard and similar to lignum vitae, which it may be used to replace. Large pink flowers form in showy terminal panicles and the fruit is an elliptical pod about two inches long, containing the seed known as the "Tonka bean". The ripe fruit is pale brownish yellow and the seed is covered by a pulp that is very attractive to bats, which in consequence do considerable damage to the crop.

"Natural coumarin is used for several purposes by the natives of the countries where the tree is indigenous, not only for perfumery, but also to fight insects of varying kind. In Brazil, *Dipteryx odorata* has been largely destroyed, as a timber tree, and the coumarin is obtained from two smaller species, *D. polyphylla* Hub. and *D. speciosa* Ducke, the seeds of which, however contain a smaller percentage of the product than those of *D. odorata* ".

The seeds contain about 25 per cent. of solid fat. L. E. Andes in "Vegetable Fats and Oils" gives the following details:—

Tonka Butter.—The Tonka bean, *Coumarouna excelsa*, yields a solid fat, which is known as "Tonka butter", and is employed for the purpose of flavouring food. It has a specific gravity at 100°C. of 0.888; a melting point of 28°C.; acid value 7; saponification value 257; volatile acid value 5.4; and Zeiss butryo-refractometer reading 47°.

The tree is reported to produce a copal-like resin in the leaves, stems and fruits. The fruits contain up to 16 per cent. The bark when incised exudes a juice which yields a kino like product of fair quality, completely soluble in warm alcohol.

Climate, Rainfall and Altitude.

The Tonka bean tree is essentially a tropical plant which does not mean that, like cacao, it depends on a high atmospheric or soil humidity. Indeed, under cultivation in Trinidad, Tonka bean trees appear to thrive very well in the open, with a heavy rainfall (60 to 100 inches), in reasonably free draining soil.

In Trinidad, Tonka bean trees *will* grow remarkably well and one would judge from this that rainfall and temperature appear to be favourable. In the Tamana district where there is a large plantation of Tonka beans, many of the trees of which are more than 30 years old, the annual rainfall is usually over 100 inches. All along the Northern Range and the Eastern end of the Central Range Tonka bean trees grow equally well with a rainfall of 60 to 90 inches. There do not happen to be Tonka beans growing in Trinidad where the rainfall is much under 60 inches but in dry years they stand up quite

(1) T. I. Potter, XXXII, May, 1932 and XXXV, November, 1935.
A. J. Anderson, XXXII, August, 1932.
(2) E. B. M., VI, Nos. 2 and 3, 1935.

well on shallow gravel soils. Thus the range of rainfall which can be tolerated is probably wider than the 60 to 110 inches which the trees receive in Trinidad.

The trees appear to be tolerant of a fair range of altitudes. They are growing quite well as low as 40 to 50 feet above sea level below which they have not been tried and are thriving in Trinidad on steep slopes of the Northern Range up to nearly 1,000 feet. There is no sign that the trees are in any way different at 1,000 feet than at 40 feet and if the higher hills could be cultivated there seems no reason why Tonka beans should not thrive at altitudes over 1,000 feet.

Soils.

Very little is known of the natural conditions under which the tree occurs in South America. Presumably, since it occurs in close proximity to navigable rivers, it is growing on the rich alluvial vegas of those rivers. These vegas are said to be composed of rich brown loam soil to a depth of several feet and to have a thick mat of debris on the surface, which means that the surface layers of soil are well supplied with humus.

In Trinidad it has always been believed that Tonka beans thrive best on the poor soils of the Northern Range and this belief has been interpreted to mean that the tree needs the poorest soil and the minimum of care and attention. This is probably an entirely erroneous impression caused by the fact that the Tonka bean will grow where cacao and other crops failed on account of poor soil. However, experience has shown that in the Northern Range these trees grow much faster if well cared for than if left according to custom to fend for themselves in bush. An experiment at River Estate has proved that good planting, careful weeding, and mulching with pen manure can bring some trees to bear in less than one year as against the average of seven to ten years for the colony. The same experience has been obtained in other West Indian islands.

The secret is not that the Tonka bean requires a poor soil but that it likes a free draining, or well drained, soil and the bulk of poor soils in the Northern Range are naturally very free draining. Given a free draining soil the rate of growth and earliness of bearing depend on the actual soil fertility.

All the Northern Range schists and detritals appear to be suitable for this crop but the latter would need manuring; the Caroni sands series and poor Brasso sands would be suitable also with manuring. Heavy bearing trees are reported on the Moruga sands and silts but since these are often infertile, manuring would again be needed to obtain good results. On the highly calcareous marls the Tonka bean has been tried without success so presumably it is not a lime-loving plant. Very few trees have been planted on heavy acid clay soils, the reason being that the soil was considered unsuited to the Tonka bean but recently new plantings have been tried on Red Weathering Clay around Rio Claro and Poole with some measure of success, provided the soil is well drained and the seedlings are well planted and mulched. No records of bearing on these soils are yet known.

System of Cultivation.

Preparation of Land.

The area to be planted should be cleared of all large trees and preferably clean felled, early in the dry season. The whole area should then be lined according to the spacing decided upon, and it is probably best to plant it thickly with ground shade—corn, cassava, pigeon peas, tannias or bananas being all suitable. Some planters, however, prefer to let the bush form the ground shade and to keep lanes cleared through the bush to give the young plants air and light. In this latter method it is preferable to make the lanes at right angles to the prevailing winds and to break them at intervals. Once the seedlings have reached a height of six feet they need no more shade, in fact if they still have shade they are apt to grow spindly and refuse to branch.

Seed Selection.

In the past, this work has been neglected more than for any other crop, for even cacao supplies were grown from promising looking pods rather than poor ones. Even to this day the majority of planters consider that although selection is good in some crops, "a Tonka bean is a Tonka bean". No doubt this accounts in part for the present poor yields. In selecting parents one is continually baffled with old trees which produce a large crop in one year and nothing in the next two. The only thing to do at present is to watch certain possible trees for several seasons and select as parents those which bear the largest aggregate of fruit.

Nurseries.

Although many planters prefer to plant beans at stake in the field there are certain advantages in growing plants in a nursery and transplanting later. The preference for planting at stake arises from the skill and care necessary to replant small seedlings, which succumb very easily to breaking of the tap roots or other damage. Transplanting always has its risks with unskilled labour such as is employed in Trinidad but by sowing at stake the supervision needed and work necessary for successful rearing is much greater than for nurseries. One very great drawback to planting at stake is the presence of the rotting pod which attracts rodents to dig up and carry off the whole fruit. The nursery can be wired in if necessary to save this damage.

In sowing a nursery a site of sandy or light loam soil, well drained and lightly shaded is selected. This is forked thoroughly and the soil made as fine as possible. The whole fruit is pressed into the soil leaving one-third to one-half of the stalk end exposed. Some planters recommend planting the fruit at an angle of 45° rather than vertical or even horizontal. Water is applied according to needs, the soil being kept tolerably moist and never allowed to dry out.

The fruit should begin to split after about four weeks and a large number of plants can be saved by assisting the cotyledons and shoot in getting free of the fruit shell where they appear to have some difficulty in doing so naturally. The seedlings are lifted from the nursery as soon as the first few leaves have formed, and planted out in the field. Before lifting they should be thoroughly watered. They should be transported *en pilon* with plenty of soil and be kept well shaded.

Alternatively for ease of transport from the nursery Tonka beans may be planted in large bamboo pots. The two methods of procedure are :

(1) to plant the whole fruit as in the nursery bed or

(2) to crack the fruit and just plant the brown seed.

In the former case germination is slow, the emergence of the cotyledons requires help but the resulting plants are very sturdy. In the latter case removal of the fruit wall allows rapid germination (one to two weeks as opposed to four to six weeks) but from one report received the young plants were very liable to pest attacks and only a poor percentage of successful plants was ultimately obtained.

One planter finds the following method of procedure gives good results :

> "Fill the bamboo pot to top fairly tightly, make slight cavity and plant the bean at an angle of 45° stem end upwards. Keep in a shady place and do not water too heavily. More water will be needed when germination commences—never allow pots to dry out. Planting in permanent position can be done safely as soon as the cotyledons drop (about three weeks after germination)."

For planting at stake it is often recommended to use the whole fruit but to pare away the bulk of the soft tissues since the smell of these during rotting attracts rodents. Soil should be prepared for a radius of two feet from the picket just as for the nursery. The fruit should be planted just as in the nursery. Three cassava sticks if planted at corners of a triangle about two feet away from the picket give light shade to the growing seedling. It is good practice to plant two or three fruit at each picket to provide for germination failures. Where all fail, a spare seedling from another picket may be transplanted provided this is done early and carefully. One plant should be finally left at each hole.

Transplanting.

It is commonly accepted that although very small seedlings—about eight weeks old—can be successfully transplanted, older seedlings are not so easily moved. The reason is said to be due to the breaking of the tap root which may be as long as 18 inches on a 12 months old seedling.

Quite recently planters have experimented with plants three and four years old and in many cases they have been moved *en pilon* quite successfully. It is usual to cut back the branches hard before lifting. Some of these transplanted trees have borne flowers shortly after moving.

Root System.

In the young seedling a long tap root develops early and if grown in bamboo pots often emerges from the base before the plants are put in the field. Since Tonka bean trees were known to grow and survive a drought in sandy or gravelly soils it was always supposed that they possessed a long and well developed tap root which supplied water from the subsoil during the dry season.

Several trees have been excavated during the last two years and not one of them has possessed a tap root more than 24 inches long. What tap root there was ended abruptly at this depth and anchor roots from ground level descended at an angle several feet into the soil. The feeding roots spread just under the surface of the soil far beyond the spread of the branches in most cases.

Spacing.

Opinions differ as to the correct spacing for Tonka beans because old trees occupy so much room. Some planters prefer to plant at 48 feet apart in order that there will be no fear of the trees requiring thinning for at least 30 years, while others prefer to plant closer and thin out as required. The former method is good where the Tonka beans are interplanted with some other crop such as coffee or cacao where they function as shade for the other crop. For a pure stand, however, it appears preferable to plant at, say, ten feet, particularly if early bearing trees can be used, for, by the time they need thinning at ten years of age, those which are marked for removal will have already made a profit on reaping costs and thus help pay off the cost of cultivation of the area.

The systems adopted at River Estate are three :

(1) To plant at 48 feet in poor cacao fields where the cacao is gradually being replaced as it dies by coffee.

(2) To plant at 20 feet alternating with coffee, *i.e.*, each Tonka bean seedling has four coffees, each at ten feet away.

(3) To plant at ten feet and when the fastest growing areas need thinning to mark with paint all alternate trees for removal as soon as they touch against their neighbours. When the first thinning has been completed, *i.e.*, all marked trees removed, a second systematic marking is made for the next thinning and so on. Thus, the final position will be some multiple of ten feet spacing depending on the needs of the trees.

With the possibility of heavy early bearing trees being selected and propagated this last method will be very efficient.

Growth Rate.

It is unfortunate that the method of rearing Tonka beans in Trinidad has been so primitive in the past, because the treatment which a plant undergoes in its earlier life probably reflects itself on the tree later ; and low yields may follow as a result of early neglect.

IMPERIAL COLLEGE OF TROPICAL AGRICULTURE.

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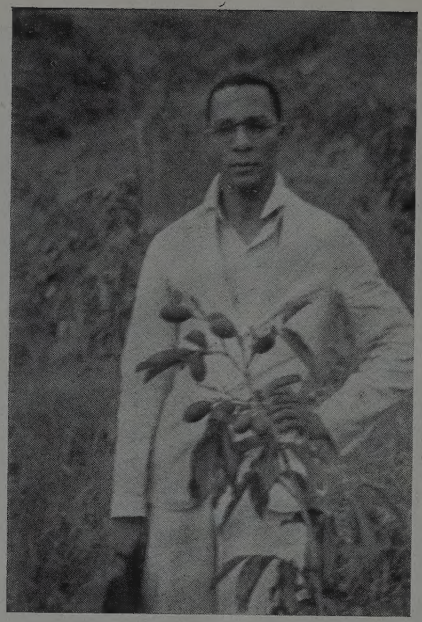

FIG. 1.—*Tonka bean seedling 18 months old with mature fruits.*

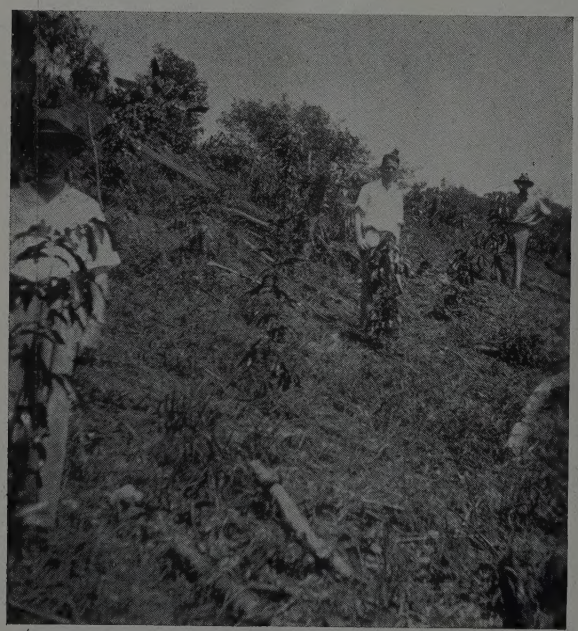

FIG. 2.—*Row of Tonka bean seedlings 13 months old, average height of whole field more than three feet.*

Generally, on the Northern Range soils, Tonka bean trees have in the past come into bearing at an average age of seven to ten years although it was well known that some would bear earlier and others be as much as 15 years old before they bore. To speculate on the price of a crop ten to 20 years from the time of planting is a great risk. Therefore, it is imperative that some means of accelerating the growth of the crop should be found. Many young plantings of Tonka beans were inspected in Trinidad where the saplings were hard, stunted and slow, where the leaves were yellow and where coarse bush covered the plants completely for most of the year. In view of these observations it was agreed to plant a field at River Estate according to the following plan to see whether good treatment produced earlier bearing and better growth.

An area of five acres was cleared in May and June, 1935, on a poor hillside which was just supporting cocorite palm and other hard bush. It was slightly burnt in July for ease of working, lined at ten feet by ten feet, planted with ground shade, and seedlings two months old were carefully transplanted *en pilon* from a nursery during the first week of October, 1935. The ground shade was planted thick but always kept clear of the Tonka bean pickets which were continually mulched with rotten wood and other debris. Corn, pigeon peas and bananas made up the ground shade. At six months the corn was cleared and much of the pigeon peas and a basket of pen manure added to the mulch around each Tonka bean seedling. At 13 months the field was checked. There were less than five per cent. of missing trees, the average height of all survivors was over three feet and 20 were fruiting. On checking one month later over 100 were found to be bearing fruit which was removed from all but two. These two seedlings held their fruit and matured six and eight pods respectively, which meant that they produced a profit at the age of 18 months.

At the age of two years all the plants in the field were topped as they reached six feet high to encourage them to branch and form a head.

It is common on other estates and even among the contractors at River Estate to find at least 50 per cent. of seedlings dying through lack of attention during the first year. Those which do not die usually take on a hard stunted appearance and "hang fire" for perhaps another year. In some cases where this occurs the seedlings may spring into life after this period and grow rapidly, producing bigger and greener leaves, but where drainage is at fault they just remain stunted and hard. Once a tree commences to grow in this manner it usually continues to thrive without elaborate attention, but how much the initial check affects yields can only be seen when the River Estate experiment plot reaches full bearing and can be compared with other blocks.

The method of planting described at River Estate is not impracticable. The local contractors who have watched the results are now getting exactly the same effects—indeed one contractor using cassava as a ground shade has a stand of Tonka beans quite as good as that of the estate.

Tonka bean trees continue to grow until they reach the size of forest trees. Some of the oldest in Trinidad span 60 feet and are 40 to 50 feet high.

Subsequent Field Work.

Beyond cutlassing little work need be done on established cultivations. Pruning mainly consists of cutting off a few lower branches but if left alone Tonka beans are self pruning and the lower and inside branches die naturally. There is little draining done because most of Trinidad's Tonka beans grow on hillsides. On flat land and on heavy soils, drains are necessary and it is probable that this operation stands in need of improvement in Trinidad generally.

Only one plantation in Trinidad is known to be systematically manured with a mixture of artificials and the *young* trees on this plantation are much more regular and heavy bearing than on average plantations.

Owing to the nature of the soil on which Tonka beans have been planted in this colony compared with the soil they presumably grow naturally in, in Venezuela, it is probable that the incorporation of organic matter into the surface layers of soil would be advantageous and experiments have been started to test this on sites where the soil dries out badly during the dry season.

Special Method of Cutlassing.

Owing to the erratic bearing of large trees one planter whose cultivation is on sloping land has evolved a cheap method of cutlassing. Before the crop begins to fall he cutlasses only under the trees which have pods, forming the debris into a ring just outside the span of the branches. The reason for this is to save the expense of cutlassing under non-fruiting trees and to indicate rapidly to the gatherers which trees are bearing. In this way cutlassing costs have been reduced to a minimum.

No attempts have been made to test the effect of forking or other tillage, and no cover crops are grown. This is a feature which might be investigated, for the weeds of most Tonka bean fields are coarse grasses and sedges.

No shade or windbreaks are needed, indeed the Tonka bean tree forms an excellent windbreak around cacao fields.

Vegetative Propagation.

Since it has been established that the tree to tree variability in yield is appreciable the need for selection work has led planters and the Department of Agriculture to locate certain heavy bearing trees. If these are propagated by seed, in common with most other orchard crops the progeny are not likely to be by any means uniformly heavy bearing like the parent. Methods of preserving a desirable parent true to type have been tried. Budding on to seedling stocks using the technique for cacao has been successful and is easy. Grafting can also be

accomplished with ease. The rooting of cuttings is not so easy but it is possible, and it is hoped the technique will be improved. Mossing is eminently successful if done during the wet season, otherwise the branch dies through drying out. The attachment of a water reservoir and wick improves results by this method.

A new system of layering suitable for use during the dry season has been evolved by the Manager of River Estate. It consists essentially of mossing, but the mossed branch at the point of mossing passes through a bamboo pot which is filled with good loam. Roots emerging from the moss do not meet a dry atmosphere but grow very rapidly into the moist soil of the pots. An inspection window can be made half way down the pot to indicate when rooting has taken place. This usually takes about six weeks.

After this period the branch is severed behind the pot and the layer hardened off in a shaded nursery before transplanting into the field.

Dwarf Trees.

In temperate crops dwarf varieties of economic crops have been useful either to produce a dwarfing stock if the dwarf variety is of no value or to graft on to a vigorous stock if the variety is valuable. The product may turn out to be a dwarfed composite tree which bears normal fruit. This dwarfing character occurs in Tonka beans where it seems to arise from a shortening of the internodes. The leaves are slightly smaller than normal but the fruit appear normal. The owner of these trees has agreed to co-operate with the Department of Agriculture and perform grafting experiments with the trees. A dwarfing rootstock in Tonka beans would be very valuable if it prevented the mature trees from growing to the size vigorous ones do at present.

Manuring.

A number of simple manurial test experiments were laid down on mature Tonka bean trees in 1936, but the results were not in anyway conclusive. The trees were not quick to respond and in many cases there appeared to be no response at all. The erratic bearing and amount of tree to tree variation of those which bore crop in any one year together with the irregular planting of old trees showed that it would be impossible to obtain precise results.

Recently two very elaborate N.P.K. experiments have been put down on one year old seedlings. One of these is in the form of a 7 by 7 Latin Square and the other consists of manuring 1,000 trees with five main plot treatments and one sub-plot treatment, using a single tree as a sub-plot. This was possible for the seedlings were widely spaced. In time these experiments should yield general results on manuring with lime, nitrogen, potash and phosphate.

Meanwhile provision is being made for establishing regularly planted blocks of budded trees all of one clone to study fertiliser and other effects with greater precision.

Pests and Diseases.

Tonka bean trees are remarkably free from diseases and the only pest of importance is the bat which nibbles the pulp of the mature pod. To do this the bat picks the pod and carries it to its sleeping haunts where it is eventually deposited. Thus the harvest of Tonka beans around a palm tree in a peasant's garden may be appreciable. In wet districts where shade is excessive thread blight (*Corticum* sp.) may be a serious trouble and a canker occurs which appears to do no harm.

Yields.

Young trees which began to yield at the age of one to two years at River Estate produced about six pods in the first crop. In the next crop they all flowered and fruited again. A young layered branch from a heavy bearing tree produced 20 to 30 fruit 18 months after layering, over 40 fruit in the second year and 60 in the 3rd consecutive crop. These early and continuous bearing trees were all well planted and liberally mulched.

Generally, however, both old and young trees tend to bear biennially or triennially and when they do bear they produce very large crops. This erratic bearing causes a great deal of uncertainty in the crop for the trees often fail to flower for several years or, if they flower, there is but little setting of fruit.

Consequently there are records of isolated trees which produce up to 50 lb. of beans in one year and then rest for several years while the average of the plantation stands at a yield of one to two pounds per tree only. This type of yield is nevertheless very profitable at present prices but there is no reason why it should not be improved upon.

It was pointed out in the introduction that botanically there is quite a range of characters within the cultivated species in Trinidad. Bearing capacity is probably also a character which varies from tree to tree but this is also influenced by soil and climatic conditions.

In addition to poor soil, poor cultivation when young may be also partly responsible for low yields and particularly for the slowness of response to manurial treatment. The few seedlings at River Estate which bore so early and appear, with proper cultivation, to be bearing continuously are being watched with great interest to see whether they take on the erratic behaviour of old trees at a later stage. Earliness of bearing in fruit trees usually means a short life but in most cases a profitable one. This feature will become of great importance if the policy of close planting is adopted.

Improved Strains.

In order to investigate this variation in cropping and its reasons a number of experiments have been tried on Tonka bean trees of various ages.

It was noted that when trees become crowded together they fail to bear. Manures were applied to see if the cause was root competition for food since the bulk of Tonka beans were growing on

rather poor soil. No effect was noticed which could be termed significant in the first year even when manures which were very deficient in the soil were applied. The manures had no immediate effect either in stimulating continuous, in place of intermittent cropping, even on trees not overcrowded. That overcrowding is an important factor can be seen in any field of large trees where the edge trees or those bordering an open space bear most fruit. Since fertilising appears of little immediate value on crowded trees this overcrowding factor may not be a soil factor but one of insufficient light or air, unless of course the Tonka bean tree is very slow to respond to manurial treatment.

Overcrowding, however, is not the whole explanation of poor yields for even trees growing in the open often fail to produce a crop. One planter sprayed his flower inflorescences with Bordeaux Mixture and found that he obtained a much greater survival of young set fruit but there was heavy premature fall later. It appears that the tree fails to flower, or fails to hold set fruit in certain years purely on physiological grounds and it is strange that heavy manuring has no immediate effect.

Harvesting and Preparation for Market.

In its native habitat gangs of people make excursions into the forests in crop time for the purpose of gathering the fallen fruit. A very picturesque account of this is given in Eugene Andre's "A Naturalist in the Guianas" pp. 9 and 10, which reads: "All through February and March, the Caura, so deserted at other times presents a scene of activity; many boats are met with struggling against the powerful current of the stream, from the large *bongo* or dug out of several tons, with an entire family, to the frail skiff handled by two men. Those of a more enterprising disposition fit up expeditions of two or three *bongos* and employ quite a number of hands. This is a time of plenty for the inhabitants of the place. Progress up the river is slow and the boats make frequent stoppages for the purpose of purchasing fresh provisions and rum. Wherever there is a settlement the men will land and most of them get drunk. The old visitors usually stop at the spots leading to the sarrapiales with which they are familiar: they know every inch of ground, every tonca bean tree in the district. Cano Guayapo, Suapure, Temblador, and La Prison are the settlements where most of the boats stop. Some of the more energetic sarrapieros push on as far as Cangrejo, but it is hard and risky work getting through the rapids of Mura and Piritu. So soon as a party has selected a spot as a centre of operations, the men build the ranchos or huts which for two or three months will be their home. If the fruit has commenced to fall, collecting begins at once; if not, the men wander about the forest noting the spots where fruit is plentiful, or they while away the time fishing and hunting. Every member of a family or party—man, woman, and child—takes part in the collecting.

At daybreak the work commences, the workers separating so that no fruit-bearing tree may be overlooked. After the trees in the immediate neighbourhood of the ranchos have been exhausted, sarrapieros wander farther into the depths of the forests; often they undertake expeditions to considerable distances and remain a week or a fortnight away.

During this time they sleep in the forest, slinging their hammocks between trees with a light covering of wild plantain leaves or palm branches to keep the rain off.

The fruit of the sarrapia is much like the mango in appearance and is largely eaten by the natives. It has but little pulp, which is sticky and of insipid taste, the seed being covered with a hard fur-like substance. After the sarrapiero has got together a sufficient quantity of fruit, he takes his find to some open spot where he can get the benefit of strong sunlight. The hard shell is then carefully broken between two stones and a single bean of a dark brown colour obtained. The seeds are then spread out to dry, generally upon the large open masses of granite called lajas which form so peculiar a feature of the forests of this region. These dried beans form the sarrapia or tonca-bean as it is sold by the sarrapiero to the merchants of Ciudad Bolivar where the process of crystallization, as it is called, is sometimes carried out. This operation, however, costs very much less if performed in Trinidad, where the strong rum required for the process can be obtained at a cheaper rate than at Ciudad Bolivar.

By the end of May or the beginning of June the last beans have been taken, and the crop may be said to be over".

In Trinidad there are no excursions of this nature. During the crop months of March, April and May the dropped fruit are gathered every two or three days usually by women and spread on drying trays to ripen off. When freshly dropped the fruit is green in colour or faintly brown and the flesh is firm. The drying process causes a softening of the fleshy tissue and shrinkage of the outer skin. As soon as this is considered satisfactory the pods are opened by tapping smartly with a hammer or stone along the suture. This causes the pod to fall into two halves and the single bean is extracted. It is usually of a dull mahogany colour, 1½ to 2 inches long, and about ½-inch wide. The majority of beans are somewhat wrinkled when they are extracted but occasionally "bloated" or "bloater" beans are obtained. These are not liked by the trade for they do not shrink as normal beans but they come from normal trees and are quite viable.

The drying is continued after extraction in the shade for one or two days and then the beans are bagged and sold. The trade prefers a long bold bean of deep colour but not black, nicely wrinkled and firm. Light and black beans are considered as second quality.

(To be concluded.)

RAPID SOIL ANALYSES.

[The following article, which was issued by the Imperial Bureau of Soil Science at Rothamsted, England, as a Monthly Letter, dated September, 1937, defines the present attitude towards rapid chemical soil tests maintained by most experienced agricultural chemists ; its conclusions are fully endorsed by the members of the staff of the College Department of Soil Science. Its reprinting in the College Journal is intended to indicate to our readers the degree of reliance which may be placed in this popluar recent development of soil chemistry.—EDITOR.]

THE use of rapid semi-quantitative methods of soil analysis has made great strides in the United States during the last few years. Several complete outfits have been put on the market for carrying out rapid analyses which have become standard practice in many State institutions. We are not in a position to criticize or recommend the methods, but they are now firmly established and are attracting the attention of soil chemists in other countries than the United States.

Spurway's field test (15) for water soluble phosphate is a good example of one of the earlier rapid methods. A little of the soil to be tested is placed in a piece of waxed paper folded to form a trough, then a few drops of water are allowed to run down the tilted paper, through the soil, until a little percolate collects at the lower end. The percolate is drawn onto another waxed paper, a drop of ammonium molybdate solution in nitric acid is added, and the mixture stirred with a tin rod for ten seconds. If water soluble phosphate is present a blue colour develops, the tint depending on the amount of it in the soil. By comparing the tint with that of appropriate standards of known phosphate content, the relative availability of phosphate may be judged.

The ease and rapidity with which such a test can be carried out in the field by an unskilled person drew attention to the possibility of extending the method to determine other soil constituents. Spurway's method was quickly followed by others adapted for the determination of available potash, available nitrogen, soil acidity, lime requirement, magnesium, iron, maganese, sodium, sulphates and chlorides, &c. Instructions and apparatus for carrying out rapid tests have been marketed under such names as the " Hi-Lo " test for phosphate (2), Spurway's " Simplex " soil testing outfit (16) and Morgan's " Universal " soil testing kit (13). These tests are the same in principle as Spurway's test for phosphate, except that most of them employ an acid reagent buffered with a salt to make the soil extract. Potash is generally estimated by the turbidity produced with sodium cobaltinitrite, nitrates by the blue colour developed with diphenylamine and sulphuric acid, and so on. Colour charts are generally supplied for matching the tints developed in the different tests. They may indicate the amount of the soil constituent as very low, low, medium, high or very high, or more boldly express the result in pounds per acre. They are not all, strictly speaking, " field " tests ; as cleanliness is usually important, they are best carried out in the laboratory.

Though these tests have the obvious advantages of rapidity and cheapness their limitations are just as apparent. Their utility depends not only on the accuracy of the test but on the interpretation of the results in terms of fertilizer practice. Rapid methods are essentially modified micro-chemical methods. The soil is measured by volume, usually in special containers, and the test thus begins with an approximation. Most of the methods make provision for the separation of the extract from the soil, but with some soils especially organic soils, it is often difficult to obtain extracts clear enough to get an accurate colour comparison. Colour matching is made difficult without a standard source of illumination, and as in all micro-chemical tests the use of faulty or slightly contaminated reagents may render the results valueless. Another important factor is soil sampling, and all the instructions given with rapid methods lay particular stress on this point. A composite sample is usually prepared, according to a definite scheme, from soil taken from, say, twenty places in the same field.

The correct interpretation of rapid chemical tests calls for a good deal of experience with them and with the soils and crops under consideration. Anderson and Noble (1) have recently compared various quick chemical tests, and in summarizing the results refer to their use in several State laboratories as follows : "..... in these institutions the tests are made and interpreted by agriculturists who have had broad experience with the groups of soils tested. Furthermore, they have definite knowledge concerning the nutritional requirements of the crops normally grown and of the adaptation of various crops to particular soil types, as well as a knowledge concerning the response of these crops to fertilizer applications under different conditions. With this background of experience, quick chemical tests are often found to be a great aid in making interpretations helpful for practical purposes ". Much the same opinion is expressed by Conrey (5) who states that 90 per cent. of the information needed to interpret the results is obtained from previous knowledge of the soils and crops, and only 10 per cent. from the test itself. This type of statement is, however, true of any method of soil analysis.

Latterly Hance and others in Hawaii (9) have conducted a critical study of rapid chemical methods which has led to the adoption of these tests in improved forms throughout the sugar plantations. Many improvements have been made in the methods themselves, for example in the turbidity test for potash a mechanical rotator

has been substituted for hand shaking, thus eliminating errors due to the operator. Colour matching is carried out in a simple illuminator. All the reagents used are accurately made up and checked at a central laboratory and a constant watch is kept on the accuracy of the tests made on each plantation by means of check samples forwarded to the central laboratory. R.C.M. (Rapid Chemical Method) experts visit the plantation laboratories at regular intervals and give advice and practical help in carrying out and interpreting difficult or doubtful tests. Faded colour standards (solutions of organic dyes are used) and faulty reagents are replaced and everything possible is done to ensure the accuracy and reliability of the tests. They are used to indicate soil areas of similar nutrient status where Mitscherlich tests or occasional simple field experiments may most profitably be undertaken. The wholesale adoption of these tests on the Hawaiian plantations as the stock method of analysis of both soil and plant material indicates the modern tendency towards valuing time above accuracy and quantity above quality in routine analysis. Where the sampling error is in any case high, a strong case can be made out for this tendency.

A fair correlation between the tests and field responses is usually obtained though naturally nobody claims infallibility for the tests. The general impression received from published papers on the subject is that rapid tests, even if they have served no other purpose, have kept alive the waning interest among farmers and growers in soil analysis—a matter of some importance, both to the soil chemist and the purveyor of fertilizers. The ordinary farmer is not impressed by a sheet of analytical figures (perhaps qualified by a cautionary but honest note as to their significance) nor by the laborious processes by which the figures are obtained. But when once his interest is aroused by a dramatic colour change produced by his soil, it can be maintained, and, if necessary, diverted to serve the needs of both science and commerce. In this respect, rapid soil tests have been a signal success in many American States, nor can it be stated that they have been any less effective than older methods in telling the farmers the little that chemistry can usefully tell them about their soils.

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NOTES ON THE CONTROL OF MANGO ANTHRACNOSE (*COLLETOTRICHUM GLOEOSPORIOIDES*).

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In Trinidad and other West Indian Islands the 'Julie', 'Peter', and other varieties of mango are often severely attacked by *Colletotrichum gloeosporioides*. Mangoes are attacked by this organism at two stages in their development; firstly, at the time of flowering, when a 'blossom blight' is caused, and secondly as the fruit ripens when the disease is a typical anthracnose.

In Trinidad the mango trees start to flower in January at the beginning of the dry season, and may continue to put out flowers for two or three months. The early flowers are often severely attacked by blossom-blight, especially if the wet season has been unduly prolonged as it was in January 1937. The scarcity and lateness of the 1937 mango crop was probably largely to be attributed to this attack of blossom-blight and the consequent failure of the early flowers to set fruit.

In addition to blossom-blight, *Colletotrichum gloeosporioides* is the cause of anthracnose, the most serious fruit-rot of the mango. Black spots, which later become sunken, develop on the fruit shortly after it is ripe, or even before in some instances. Later the spots coalesce and in a few days at tropical temperatures the whole fruit is involved. The acervuli and spores of the fungus develop as pinkish masses on the sunken spots. The spots are often concentrated at the stem-end and sometimes in stripes down the sides of the fruit, suggesting that the spores of the fungus are distributed in drops of water which, running down the stalk of the fruit, collect at the stem-end and finally run down its sides leaving a deposit of spores.

Wardlaw and Leonard (3) in their investigations on the storage of West Indian mangoes state that wastage (largely due to anthracnose) is serious, and that it is unlikely that in the class of fruit produced under Trinidad conditions the total commercial wastage can be curtailed to the customary ten per cent. allowed for other fruits. They continue to state that since rotting is almost entirely due to pathogens established as latent infections during growth the extent to which wastage may be reduced by spraying operations requires careful investigation. Baker and Wardlaw (1) have demonstrated that the latent infections of *Colletotrichum gloeosporioides* are established in mangoes at an early stage in the life of the fruit, in many instances the fungus being present in the skin of the fruit within a fortnight of flowering. It was thought possible, therefore, that a protective spray applied to the fruit at the time of flowering, followed up by additional sprays as the fruit developed, might prevent the latent infections of this organism from becoming established, and during the 1937 mango season a preliminary spraying trial was carried out to test this theory. Four Julie mango trees were sprayed once a week with one per cent. Burgundy mixture from the time when the first flowers were produced in January until the fruit was harvested in May, June or July. A Vermorel Headland spray pump fitted with a spray gun and working up to a pressure of 200 lb. per sq. inch was used, and the tops of the trees were easily reached without a lance. The Burgundy mixture was prepared fresh each week and two or three gallons were used per tree. Only the flower spikes and fruits were sprayed, no attempt being made to cover the leaves. It is obviously uneconomic to spray mangoes as often as this, but the object of the experiment was to determine whether it was possible at all to control mango anthracnose by a protective spray. Further experiments next season will be made to determine the minimum number of sprays necessary to control the disease, and also the best time of application. Four other trees of the same variety were left unsprayed as controls. Striking results were obtained in the control of anthracnose, but the control of blossom-blight was not so satisfactory. Although more than twice as many fruit were set during January on the sprayed as on the unsprayed trees, by the end of February the unsprayed trees had set nearly as many fruit as the sprayed trees, and unless early fruit obtained a much higher price than mid-season fruit, the spray would have been uneconomic.

Blossom-blight caused by the same organism also constitutes a serious problem in Florida. McMurran (2) found that serious damage was done in moist showery weather, and that under such conditions spraying with Bordeaux mixture had little or no effect.

Fruits from sprayed and unsprayed trees were harvested on 7th and 18th May and 24th June and stored in the laboratory at tropical temperatures. The fruit was picked as near as possible to full grown, but while it was still green and hard. Fruit picked for export would probably be taken when slightly less mature than the above. All the fruit ripened within ten days, the majority on the fifth or sixth day after picking. In Series I (Table I), picked on 7th May some difficulty was experienced in getting sufficient control fruit, and in this experiment the unsprayed fruit was probably less mature than the sprayed fruit. In the other two series the sprayed and control fruit were picked at approximately the same stage of maturity.

In all three series the difference between the sprayed and the unsprayed fruit was striking. On the unsprayed fruit the developing latent infections of anthracnose became visible as small black dots as the fruit began to ripen. These dots rapidly became typical anthracnose spots and one or two days later the appearance of the fruit was spoilt. Three or four days after ripening

had commenced the fruit was usually completely blackened and worthless. The behaviour of the sprayed fruits was markedly different. Very few anthracnose spots developed, some fruit having none at all, while the fruit ripened five or six days after picking, and remained in good condition sometimes for as long as six or seven days after they had ripened. Whilst on unsprayed fruit wastage was almost always due to anthracnose, the final cause of wastage of sprayed fruit was generally a breakdown due to senility (Tables I, II and III).

In series II and III half the control and half the sprayed fruit was thoroughly washed in running water and dried with a clean cloth immediately after picking. This treatment had no effect on the incidence of anthracnose, showing conclusively that the latent infections were established before the fruit was harvested. Wastage was slightly more rapid on the washed than on the unwashed fruits, due probably to the extra handling which they received, but the appearance of the washed fruits was much improved.

Table I.

SERIES I.—SPRAYED 21, UNSPRAYED 21 FRUIT. PICKED 7/5/37.

Days after Picking.	Sprayed.		Unsprayed.	
	Blemished.	Destroyed.	Blemished.	Destroyed.
	%	%	%	%
3	—	—	—	—
4	—	—	—	—
5	—	—	15	—
6	—	—	34	—
7	—	—	44	—
8	—	—	55	—
9	24	—	75	29
10	34	—	100	75
11	59	5	—	19
12	85	19	—	100
13	100	39	—	—
14	—	65	—	—
15	—	100	—	—

Causes of Wastage.	Sprayed.	Unsprayed.
	%	%
Anthracnose	19	100
Stem-end Rot	19	—
Senility	62	—

Table II.

SERIES II.—SPRAYED 50, UNSPRAYED 40 FRUIT. PICKED 18/5/37.

Days after Picking.	Sprayed.		Unsprayed.	
	Blemished.	Destroyed.	Blemished.	Destroyed.
	%	%	%	%
3	—	—	—	—
4	—	—	—	—
5	—	—	12	—
6	2	—	27	2
7	10	—	57	10
8	14	4	75	20
9	18	6	90	40
10	34	6	100	62
11	56	10	—	87
12	100	22	—	95
13	—	46	—	100
14	—	100	—	—
15	—	—	—	—

Causes of Wastage.	Sprayed.	Unsprayed.
	%	%
Anthracnose	44	98
Stem-end Rot	—	—
Senility	56	2

GRAPH NO I SERIES III

RATES OF RIPENING, BLEMISHING, AND WASTAGE OF SPRAYED AND UNSPRAYED JULIE MANGOES.

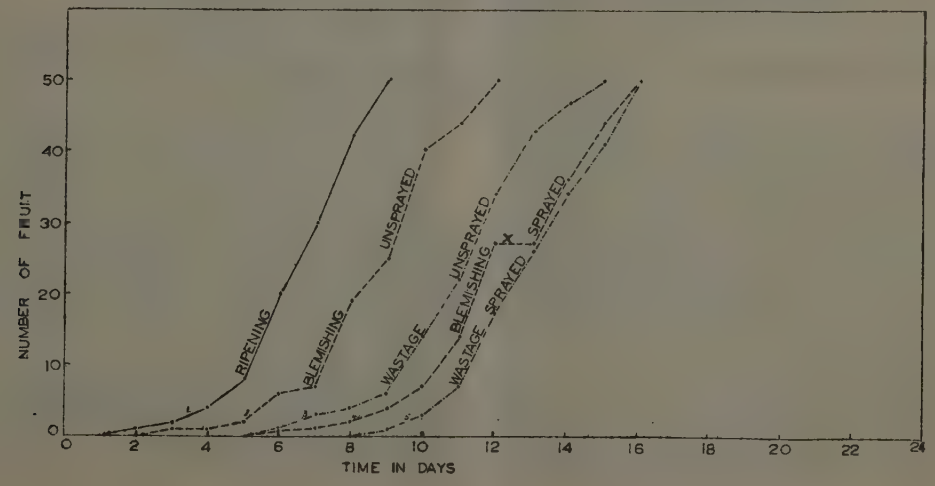

Table III.

SERIES III.—SPRAYED 48, UNSPRAYED 48 FRUIT. PICKED 24/6/37.

Days after Picking.	Sprayed.		Unsprayed.	
	Blemished.	Destroyed.	Blemished.	Destroyed.
	%	%	%	%
3	—	—	2	—
4	—	—	2	—
5	—	—	4	—
6	2	—	12	2
7	2	—	14	6
8	4	—	38	6
9	8	2	50	12
10	28	4	80	28
11	44	14	88	44
12	54	34	100	68
13	54	56	—	86
14	74	68	—	92
15	88	82	—	100
16	100	100	—	—

Causes of Wastage.	Sprayed.	Unsprayed.
	%	%
Anthracnose	34	98
Stem-end Rot	7	—
Senility	59	2

In series III, in addition to being washed, half the fruit were wrapped in ordinary paper fruit wrappers. This treatment had no effect on the rate of ripening of fruit, the rate of development of anthracnose or the amount of wastage.

The results of the above three series are given in Tables I, II and III, and in Graph I.

It is evident from the foregoing results that the weekly sprayings with Burgundy mixture have been markedly beneficial in the control of anthracnose. The sprayed fruit remained in a marketable condition for several days longer than the unsprayed fruit, and wastage due to anthracnose was considerably decreased, many fruits indeed never developing anthracnose lesions. The break at point X in curve No. 4 in Graph I is of interest in this connection. Below the point X, blemishing was due to anthracnose, and approximately 30 fruit were affected, but the remaining fruit never developed anthracnose, so that blemishing was delayed until the fruit became over-ripe. The graph also shows that unsprayed fruit heavily infected with anthracnose were destroyed four or five days after ripening, but that the less heavily infected sprayed fruit lasted at least two days longer. The appearance of the unsprayed fruit was spoilt four or five days before that of the sprayed fruit.

These observations may be of considerable practical value to growers of Julie mangoes since the success or failure of an export trade in mangoes will depend to a large extent on the preservation of the fruit in the hands of the retailer for a reasonable period after it is released from cold storage. The observations of Wardlaw and Leonard (3) suggest that unsprayed Julie mangoes break down very rapidly on release from cold storage, wastage being mainly due to anthracnose. It is reasonable to assume that mangoes protected from anthracnose infection by spraying will remain in good condition for a longer period on their release from cold storage, and it is hoped that it will be possible to test this theory during the 1938 mango season in addition to determining the minimum number of sprays necessary for the control of anthracnose and the best times for their application.

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SEA ISLAND COTTON ASSOCIATION MEETING.

Summary of the Proceedings of the Second Ordinary General Meeting of the West Indian Sea Island Cotton Association (Incorporated).

THE second ordinary general meeting of the Association was held in Antigua from 17th to 23rd November, 1937. The meeting was formally opened by His Excellency the Governor of the Leeward Islands. The business sessions of the meeting were conducted under the chairmanship of Mr. G. A. Jones, Commissioner of Agriculture, and President of the Association.

The following members attended the meeting :—

MR. E. D. DEW.—Antigua Cotton Growers Association.

MR. A. DE L. INNISS.—Barbados Cotton Growers Association.

MR. O. R. KELSICK.—Montserrat Cotton Growers Association.

MR. W. E. WALWYN.—St. Kitts Sea Island Cotton Growers Association, Limited.

MR. W. J. ABBOTT.—The St. Vincent Chamber of Agriculture and Commerce (Incorporated).

Mr. C. C. Skeete, Assistant Commissioner of Agriculture attended as Secretary. Mr. W. B. de Grasse, representing the Nevis Cotton Growers Association, which has not yet applied for membership of the Association, also attended the meeting.

The St. Kitts Sea Island Cotton Growers Association Limited, which recently became a corporate body, applied for and was admitted to membership of the Association.

The meeting placed on record its great appreciation of the part played by the late Professor H. A. Ballou, C.B.E., in establishing and fostering the Sea Island cotton industry in the British West Indies and of the services rendered by him in the formation of the West Indian Sea Island Cotton Association.

The report of the Board of Directors for the year ending October, 1937, and the audited statement of income and expenditure for the period 25th November, 1936 (the date of incorporation of the Association), to 31st March, 1937, was presented to the meeting. The report of the Advisory Committee in England for the year ending September, 1937, was also presented to the meeting. The latter indicated that the more important matters which engaged the attention of the Advisory Committee during the year were the publication of market information, the administration of the certification trade mark, misrepresentation of cotton goods, and advertising. The Committee moreover endeavoured to encourage the commercial development of Sea Island cotton and wool mixture yarn, produced as a result of experiments conducted by the Wool Industries Research Association, and in other ways endeavoured to extend the uses of Sea Island cotton.

Statistics placed before the meeting showed that production in 1937 had fallen short of estimates. The slump in the cotton market during the middle and latter part of the year 1937 resulted in the accumulation of stocks in relatively small quantity. The market situation was however considered such as to warrant the production of two million pounds of lint in 1938, and the meeting agreed that there was no need for the operation of legislation to restrict the exports of cotton lint during the year 1938.

A scheme for the organization of the cotton breeding station in Montserrat as a central cotton breeding station for all the Islands cultivating the Montserrat strain of cotton was accepted by the meeting. It was decided also to contribute the sum of £150 per annum from the funds of the Association to the Government of Montserrat towards the cost of maintaining the station provided the scheme proves acceptable to the Montserrat Cotton Growers Association.

Mr. F. A. Squire, Entomologist for cotton pest investigation in the Windward and Leeward Islands, attended the meeting and reported on the progress of his investigations during his first year in the Islands. The meeting discussed various proposals put forward by Mr. Squire and made several recommendations for the institution of regulations which had as their main object the more efficient control of cotton pests in the field and in ginneries.

The question of biological control of pink boll worm was also discussed with the Entomologist and it was agreed that no action could be taken in this direction during the coming year. It was however decided to ascertain what measure of success had been achieved in those countries where parasites of pink boll worm had been recently introduced.

The attention of the meeting was drawn to the action which has so far been taken by the Imperial College of Tropical Agriculture and the Governments of the Eastern Islands of the British West Indies to prevent the introduction of the cotton boll weevil now known to exist in Haiti. The meeting was informed that existing regulations in the various Islands were as yet incomplete and inadequate for the purpose for which they were intended, and the meeting agreed to rely on the Commissioner of Agriculture to obtain the best possible advice in the preparation of adequate regulations through the Plant Quarantine Committee in Trinidad.

On the recommendation of the Advisory Committee in England, the Association decided to participate in the Empire Exhibition at Glasgow in 1938, and authority was given to the Advisory Committee to proceed with the reservation and suitable preparation of a stand for the Association in the Colonial Pavilion at the Exhibition. The Association also authorised the Advisory Committee to proceed with the printing and distribution of leaflets designed to advertise the special qualities and advantages of Sea Island cotton goods.

The meeting was informed that a quantity of Sea Island cotton had been imported into the United Kingdom from Florida and that it had been offered for sale on the Liverpool market at prices below which the Sea Island cotton industry in the British West Indies can be profitably maintained. The meeting agreed to refer the matter to the Advisory Committee in England and to seek their advice as to what action should be taken by the Association.

Votes of thanks were recorded to the Association's Advisory Committee in England, to the British Cotton Growing Association and to the Empire Cotton Growing Corporation for their services rendered to the Association during the past year. The thanks and appreciation of the delegates was also heartily expressed for the kind and generous hospitality of the Antigua Cotton Growers Association during their visit to the Island.

THE PHYSICAL ENVIRONMENT, FAUNA AND AGRICULTURE OF THE BRITISH SOLOMON ISLANDS.

List of Addenda and Corrigenda.

P. 281, col. 1, para. 2—" Most recent review is in Geological Magazine, LXXIV, June, 1937, by author ".

P. 281, col. 2, para. 3—After Savo *delete* " this island " and *substitute* " which ".

P. 282, Map. 2—*For* " Vella Lavell " *read* " Vella Lavella " and *for* " Save " *read* " Savo ".

P. 284, col. 2, para. 2—*For* " *Mus* " *read* " *Cyromys* ".

P. 284, col. 2, penultimate paragraph, last line—*For* " vegetable fibre " *read* " mycelium of *Marasmius* or horse-hair blight ".

PLANNING FIELD EXPERIMENTS ON *COFFEA ARABICA.*

By S. M. Gilbert.
Chief Scientific Officer, Coffee Research and Experiment Station, Lyamungu, Tanganyika Territory.

Introduction.

The experimentalist is as anxious to effect spectacular improvements in the economic yield of a particular crop as the planter himself.

This laudable desire must not, however, induce him to launch numerous experiments on a crop of which he knows nothing.

Experience in other countries has shown the futility of such work, particularly on perennial trees, when information is lacking (1).

In perennial tropical crops, investigation of the planting material has been found essential to the planting of worthwhile field experiments (2), (3), (4).

The major difficulty is the enormous variability in yield between individual trees in any one season.

It was suspected that *C. arabica* would be found to be no exception to this drawback and accordingly individual tree records, on a large scale, were commenced in 1934 when this Station began to function. Two seasons' data confirm this suspicion.

Method.

One method applied for studying the feasibility of experiments and their probable success has been by means of "uniformity" trials.

In selecting areas for this work care was taken to choose blocks of coffee growing under as many different conditions as possible. The blocks are on different soils and at different altitudes all over Tanganyika Territory. Bourbon, Kent's and Blue Mountain types are represented and trees from the first year of bearing to 40 years of age are under observation. Where practicable each block contains sufficient trees to permit of 16 plots of 20 trees, with necessary guard rows, being laid out. A 4 by 4 Latin Square was used for the purpose of carrying out the analysis of variance.

In 1934 sixteen such blocks were recorded and in 1935 an additional four were included. Nearly 12,000 trees are thus under observation. Blocks uniform for age have been almost impossible to find, owing to frequent "supplying".

The object of part of the investigation was to find, for field experiments on *C. arabica*, the order of increase that must be obtained for "treatments" to show up, with the mixed population in use.

Table I.—*Plot yields in ounces of cherry*—1934.

	Estate A.				Estate B.				Estate C.			
	A	B	C	D	A	B	C	D	A	B	C	D
1	2,877	3,110	2,650	661	20	23	28	101	2,513	3,153	4,018	1,818
2	2,817	2,248	2,117	1,998	23	33	26	19	3,044	3,039	5,049	1,970
3	3,248	2,597	1,285	976	125	19	22	20	1,235	337	703	1,963
4	2,248	2,570	2,089	2,404	184	175	190	13	3,198	1,997	2,044	1,390

Table II.—*Analysis of Variance.*

	A.			B.			C.		
Due to	D.F.	Sum of Squares.	Mean Square.	D.F.	Sum of Squares.	Mean Square.	D.F.	Sum of Squares.	Mean Square.
Rows	3	253,601	84,534	3	32,404	10,801	3	11,339,195	3,779,731
Columns	3	4,156,093	1,385,364	3	4,990	1,663	3	3,008,732	1,002,911
Treatments	3	775,116	258,372	3	17,033	5,678	3	1,838,067	612,689
Interactions	6	2,857,592	476,265	6	12,609	2,102	6	5,950,294	1,255,254
Totals	15	8,042,402	—	15	67,036	—	15	22,136,288	—
Plot Mean		2,243 oz.		Plot Mean		64 oz.	Plot Mean		2,342 oz.
Significant Difference....		45.30%		S.D.		143.9%	S.D.		63.5%
Plot Error		28.3 %		Plot Error		89.9%	Plot Error		39.7 %

TABLE III.—*Plot yields in ounces of cherry*—1935.

	ESTATE A.				ESTATE B.				ESTATE C.			
	A	B	C	D	A	B	C	D	A	B	C	D
1	3,346	4,244	5,269	2,571	1,285	2,096	2,379	2,454	3,572	1,762	1,883	1,653
2	2,952	2,957	3,249	1,523	776	1,859	1,719	1,514	1,611	1,880	2,381	2,217
3	2,183	2,066	2,589	3,444	1,072	686	1,090	603	2,145	614	1,286	1,788
4	3,330	1,377	2,776	1,838	812	732	470	649	1,976	1,241	1,518	3,478

TABLE IV.—*Analysis of Variance.*

	A.			B.			C.		
Due to	D.F.	Sum of Squares.	Mean Square.	D.F.	Sum of Squares.	Mean Square.	D.F.	Sum of Squares.	Mean Square.
Rows	3	5,581,694	1,860,565	3	4,733,646	1,577,882	3	1,314,643	438,214
Columns	3	2,749,768	916,580	3	430,979	143,659	3	2,469,260	823,087
Treatments	3	1,486,425	495,475	3	365,636	121,879	3	774,526	258,175
Interactions	6	5,152,188	858,698	6	1,017,508	169,585	6	3,929,818	654,970
Totals	15	14,970,075	—	15	6,547,769	—	15	8,488,246	—
Plot Mean		.... 2,857 oz.		Plot Mean		.... 1,262 oz.	Plot Mean		.... 1,938 oz.
Significant Difference		.... 48.1 %		S.D.		.... 49.7 %	S.D.		.... 59.7 %
Plot Error		.... 30.1 %		Plot Error		.... 31.1 %	Plot Error		.... 37.3 %

Discussion of Data.

Examples from three estates are discussed here. The remaining 17 confirm these results.

Tables 1 and 3 set out the plot yields in ounces of cherry for the crop seasons 1934 and 1935 respectively.

Tables 2 and 4 analyse the variance for the three estates for the same two seasons.

It will be seen that the significant differences expressed as percentages of the mean plot yields, for any one year's results are enormous and outside the order of increase that might be expected normally from ordinary improvements in agricultural practice.

The biennial bearing habit is also brought out on Estate B. Estates A and C are relatively uniform. In 1934 the crop on Estate B was a failure.

It will be noticed that the mean yields of plots may increase or decrease out of step from their neighbours. More startling are the enormous differences in yields of different plots. For example, plots A.1C and A.4B have the same mean yield (approx.) in 1934 but in 1935 the former has yielded four times the amount of the latter. Seasons have made but little difference in others, c.f. A.2A.

In only one case has the same plot been extremely bad twice in succession. This was due to the presence of young trees.

The known factors which cause this irregularity in yield are :—

(*a*) *In the same season* :

Differences in age.

Different response to season.

(*b*) *In different seasons* :

Being out of step in " biennial " bearing habit.

Possible factors about which little is yet known are :—

(*a*) Influence of pruning.

(*b*) Genetic causes.

These factors are under investigation.

So far then it may be concluded that it would have been most unwise to have laid out experiments immediately on such material.

It was next desired to see how far this variation could be reduced by combining two years yields, thus eliminating that due to biennial bearing.

The effect has been considerable—*see* Table 5.

In Estate A the Plot Error in either year has been substantially reduced by about eight per cent. to 21 per cent. with a Significant Difference of 33 per cent. With Estate B the increase in yield from 1934 to 1935 is so great that no advantage is gained. The Significant Difference remains at about 50 per cent. On Estate C the Standard Error has been reduced by nearly 10 per cent. but still remains very high with a Significant Difference of nearly 50 per cent.

The conclusion is that three years' natural yields are desirable on such material.

As however there are certain treatments, such as mulching, which, judging by their success in neighbouring colonies, may give increases of yield of the order of 50 per cent., experiments are being attempted on four estates similar to A with only two years records of natural yield.

This is justified by the fact that increase of precision is likely to be obtained by use of the method of co-variance as outlined by Sanders (5) or possibly by a direct comparison of the mean of two experimental years with that of two years of natural yield as suggested by Cheesman (6), in connection with cacao.

TABLE V.—*Analysis of Variance.*

	A.			B.			C.		
Due to	D.F.	Sum of Squares.	Mean Square.	D.F.	Sum of Squares.	Mean Square.	D.F.	Sum of Squares.	Mean Square.
Rows	3	1,637,321	545,774	3	1,065,130	355,043	3	4,807,070	1,602,357
Columns	3	2,176,715	725,572	3	94,061	31,353	3	1,132,537	377,512
Treatments	3	673,947	224,649	3	125,768	41,922	3	997,802	332,601
Interactions	6	1,865,123	310,854	6	274,700	45,783	6	2,459,174	409,862
Totals	15	6,353,106	—	15	1,559,659	—	15	9,396,583	—
Plot Mean		2,550 oz.		Plot Mean		663 oz.	Plot Mean		2,140 oz.
Significant Difference		33.3 %		S.D.		50.9 %	S.D.		46.3 %
Plot Error		20.8 %		Plot Error		32.0 %	Plot Error		29.0 %

In addition, as the same experiments have been repeated in four localities, provided the means are approximately the same, this repetition may again lead to increased accuracy.

Summary.

Uniformity trials have been carried out and analysed on average estate arabica coffee for two seasons in three localities.

The data show that on any one estate for one season it is almost impossible to carry out precise experiments.

The combination of two seasons yields, which allows for the common biennial bearing habit, reduces slightly the order of significant differences between means.

Need for recording natural yields for two or three years prior to carrying out experiments on such material is indicated.

The possibility of increased precision by the use of the method of co-variance is noted or the possibilities of comparison of means of pairs of years might be tried.

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CACAO CULTIVATION IN GRENADA.

By F. J. POUND.

Agronomist, Dept. of Agriculture, Trinidad.

[*This article is a resumé of information supplied by Mr. W. O'B. Donovan, Superintendent of Agriculture, Grenada, and the writer gratefully acknowledges the assistance received.*]

IT is a remarkable fact that the methods employed in cacao growing in the two neighbouring islands of Trinidad and Grenada should be so dissimilar. In Grenada, salvation seems to have come along the lines of intensive cultivation of small areas while in Trinidad equally large profits have accrued in the past from an extensive system of land exploitation. In Grenada costs of cultivation are high, in Trinidad they are low but at the same time Grenada estates may in good years yield cacao at the rate of 14 to 18 cwts. per acre as against yields in Trinidad of 4 to 5 cwts. per acre. Modern tendencies in agriculture are towards intensive cultivation of smaller areas in order to cut overhead costs and for this reason the following notes on the systems employed in Grenada may be of value to Trinidad planters.

Tillage Operations.

2. Experience has proved that cacao cannot be grown profitably unless the soil is thoroughly forked periodically. In normal times Grenada planters aim at forking each field once in every three or four years. In this operation the surface mat of roots and decomposing organic matter are turned into the soil. Failure to perform this operation results in a gradual deterioration of yields and the surface "biche" on a field in Grenada is regarded as a symptom of neglect.

3. Forking is performed during the months of February and March if possible, for the disturbing of wet soil seems to result in damage to physical consistency which may take a long period to repair. The soil is forked to a depth of 9 to 12 inches and turned completely over, burying all débris in one operation. Deep forking (15 inches) may be done at intervals for greater soil aeration, but this often causes a reduction of yield in the year following forking, presumably owing to severe root disturbance or the bringing of subsoil to the surface. Pen manure is usually incorporated whenever a field is forked.

4. This method of tillage is expensive but manuring is done at the same time by turning in organic matter and weed growth is controlled for many months afterwards, which reduces cutlassing bills.

Drainage.

5. The average Grenada soils are naturally more free draining than those of Trinidad yet at the same time great attention is paid to drainage. It usually happens that the shallow drains made when the cacao was planted persist through the life of the field, being cleaned and deepened annually. Attention is paid to proper contour drains on slopes to prevent excessive soil erosion, particularly after forking.

Organic Manures.

6. Grenada planters pay far greater attention to organic manures than do those of Trinidad. The fertiliser used in maintaining their high yields is usually nothing more than pen manure. Cattle are kept on pickets in the field or in pens on the edge of the field. The system of picketing deserves a little detailed description.

7. Cows are picketed at stake singly in poor spots of the cacao field and fed there until a large heap of rough manure has accumulated. It has been estimated that a well bedded cow will produce 16 tons of manure-compost per annum, sufficient for a thorough dressing over one acre. Fodder and water are brought daily. When sufficient manure has accumulated it is allowed to commence to " break down " for a few months before application and then spread at the rate of 1,000 to 1,500 baskets per acre. (One basket = 80 lb. wet manure or 50 lb. dry manure.)

8. Final breaking down takes place on/or in the soil. There is admittedly a certain amount of leaching and loss in this method, especially during the rainy season but planters philosophically tell one that whatever is lost from the heap does not leave the field. Costs of application are necessarily low since there is little heading to be done.

9. In pens some 50 to 100 cattle are herded together. Pens are usually covered both for protection of the animals and to prevent excessive loss from washing. Cattle are often pastured by day and penned by night and by this method less fodder has to be cut but the dried droppings from the pasture have to be collected periodically and placed in the nearest pen.

10. Only in very exceptional cases is pen manure applied to the soil without subsequent forking, indeed it is usually accumulated to be spread on those fields which in the year in question are due for routine forking.

Liming and Artificials.

11. Liming usually precedes pen manuring and forking, and artificials follow at an appropriate interval. Crushed or burnt coral is used as a source of lime and spread somewhat indiscriminately at rates varying from ½ to 2 tons per acre.

12. Formerly basic slag was the most popular artificial manure but when it became difficult to obtain, nitrogen-phosphate compounds such as " Ammophos " or " Nicifos " superceded it.

Rotation of Operations.

13. Grenada planters aim at a rotation of tillage operations, beginning with liming in say February of one year, pen manuring and forking in April or perhaps left over till the following year and application of artificials within two years of pen manuring—then liming is repeated.

Pruning.

14. The high prices paid for cacao before the recent depression enabled very thorough work to be done and heavy pruning once in three to four years was the accepted routine. The trees were pruned on the depunta system to give them a symmetrical shape and to prevent too thick interlacing of branches. This systematic pruning was probably highly beneficial, for now most estates and particularly peasant proprietors have neglected this work and are suffering serious decreases in crops while those which have kept up the old style of work continue to reap heavy crops. Formerly strict attention was paid to dressing wounds with crude oil, " carbolineum", tar or even paint but since the depression of 1930-35 very little dressing of wounds has been done.

Shade and Windbreaks.

15. Grenada cacao is grown without the dense immortel canopy cacao has in Trinidad and apart from an occasional avocado, breadfruit, nutmeg or clove tree left by the labourer who planted the field there is no permanent overhead shade. Often the nutmeg and clove trees were planted with the intention of maintaining a mixed cultivation which proved not only remunerative but highly successful. Windbreaks receive more attention than in Trinidad. Hedges of Mamme Apple, Galba, Mango and African Breadnut are among the most popular varieties grown. Cloves used in this respect serve not only as excellent windbreaks but give a crop of economic value on a poor soil.

Conclusions.

16. Intensive cultivation of Grenada cacao fields serves to reduce extremes of fluctuations in water content of the soil both by providing a well aerated soil mulch through which excess water will rapidly drain away, and by forcing the feeding roots below the surface where they are less liable to drying out. In this way the cacao trees continue to thrive at all seasons of the year in spite of the absence of overhead shade, and this may partly account for the heavy cropping. In Trinidad the hungry immortel shade tree is used to provide an even climate instead of the Grenada fork. It may be impracticable to carry out forking in many Trinidad cacao fields with their stiff clays and tangled masses of immortel roots but it should prove an interesting experiment to grow young cacao entirely without overhead shade and to cultivate it intensively on the Grenada system, especially since the highest yielding plot of cacao on River Estate has been grown in this manner.

REVIEWS.

POTASH DEFICIENCY SYMPTOMS.

By O. Eckstein, A. Bruno and J. W. Turrentine, *Verlagsgesellschaft fur Ackerbau*, Berlin, 1937, pp. 107; Coloured Plates, 54; Bibliography and Index.

To quote from the Introduction "The disturbances in the metabolism of the plant, due to potash deficiency, are recognisable by a change in the colour of the vegetation, the occurrence of spots caused by a breaking-down of the tissues, and by an abnormal development of various organs which leads to a characteristic change in the entire appearance of the plant". In the magnificent coloured plates which form a notable feature of this publication, such changes in appearance for 54 different crop plants, including many tropical representatives, are clearly shown, and this forms perhaps the most instructive part of the book.

"If the nutrient removal by various cultivated plants is compared, great differences will be found—with the majority of cultivated plants, potash is removed from the soil in larger amounts than the other nutrients; . . . the typical signs of lack of potash are more marked when a potash-deficient soil is well supplied with nitrogen and phosphate; . . . the symptoms of potash-hunger are variable with the different ages of the plant; . . . and under different conditions of climate."

In order to indicate the wide variation in the nutrient requirements of different crop plants, a large coloured diagram is presented as frontispiece; this clearly depicts the great differences in the amounts of nutrients removed by various crop plants from the soil. The data tabulated below have been abstracted from this diagram, but the numerical values have been translated into pounds per acre of each nutrient [nitrogen (N), phosphate (P_2O_5) and potash (K_2O)], removed from the soil by an average crop of each plant.

Crop Plant.	N.	P_2O_5	K_2O
	Lb. per acre removed.		
Cauliflower	180	70	220
Pineapple	140	45	290
Tobacco-cigar	125	55	185
Cotton	135	90	140
Oil palm	115	50	190
Sugar-cane	75	55	170
Bean	145	40	110
Tomato	95	20	130
Maize	85	40	105
Coconut	80	35	115
Sweet potato	60	20	90
Tobacco-cigarette	70	20	65
Banana	20	20	120
Ground-nut	80	20	55
Rice	50	20	65
Coffee	50	10	60
Orange	35	20	40
Cacao	20	10	50
Tea	30	5	15

It should be urged that such figures as these in the table above ought not to be taken too literally, since plants tend to absorb nutrients in degree largely dependent on the quantity of each contained in easily-available form in the soil; nevertheless the values do furnish an indication of the variation in the total amounts of nutrients removed by different crop-plants and in the approximate relative proportion of each (nitrogen, phosphate, potash).

The first part of the descriptive matter of the book deals with the general symptoms of potash deficiency in leaf, root, flower and fruit, and with its influence on plant diseases and pests, and so on the market value of crops. The second part describes potash deficiency symptoms of various cultivated crops, such as maize (by G. N. Hoffer), fruit trees (by G. A. Cowie) and vines. Each article is translated into both German and French, and all the titles of the diagrams, photographs and coloured plates are given in three languages. A short bibliography and an index (also in three languages) concludes the book. The printing, especially of the plates, is very clear, and the binding sturdy. This book can be strongly recommended to students, and particularly to agricultural field officers and planters who will find the information very attractively presented.

* * * F. H.

CACAO FERMENTATION.

By A. W. Knapp. *John Bale, Sons & Curnow Ltd.*, London, 1937. pp. 171+48 Figs. Price 10s.

This is the first work to appear on this subject since Hamel Smith's book in 1913. Since that time, a large scattered literature has appeared, both from manufacturers' laboratories and tropical research stations, and Mr. Knapp is to be congratulated on having undertaken the task of carefully sifting this material and presenting it in a way that is at once acceptable to the scientist and the practical planter.

After a short introduction, the author considers the methods that are used for fermenting, and the most suitable conditions for obtaining a well-fermented product. Then follow three chapters on the fermentation of the pulp, in which are considered the influence of micro-organisms on the process, and the changes which take place in the pulp and sweatings. Numerous organisms have been isolated from the fermenting boxes at different stages of the process, and it appears that, while some of these organisms are distributed in all the cacao-producing countries, some are specific to particular countries. As yet there has been no move on the part of planters to control scientifically the fermentation process by using pure cultures of yeasts, bacteria and fungi. Although there are objections to the method, only further research can prove whether such a procedure might be beneficial in producing a more uniform product—a desideratum for which the manufacturers would sacrifice something of quality.

Four chapters are devoted to a discussion of the changes which take place in the bean and the factors leading to the death of the bean. The formation and composition of the sweatings, the enzymes present, and the tannins of cacao are all considered.

In another chapter, Mr. Knapp examines critically the controversial question of acetic acid production during fermentation, and concludes that, in normal fermentation, the production of acetic acid is unavoidable, and its presence during the early stages of fermentation of Forastero cacao has some advantage in producing the initial changes earlier. In the final product, its presence is without advantage, and, in some respects, undesirable. Alternatives to fermentation, in which no acetic acid is produced, have so far resulted in a product inferior to the one obtained by the well-established methods, and it is likely to be a long time before these are superseded.

The chapter dealing with the effect of ripeness of pod and improved methods of fermentation, is of special importance to the planter. McDonald's solar fermentary might well receive more attention from the planter who produces only a small amount of cacao.

The book concludes with a survey of the question of drying, and the advantages of both natural and artificial methods are discussed.

Mr. Knapp has compiled a very useful bibliography, which is conveniently arranged in chronological order. The appearance of the book is timely in giving a critical and up-to-date survey of a somewhat scattered and controversial literature, and should be instrumental in stimulating research and improving the methods of the cacao planter.

E. C. H.

* * *

TEXTBOOK OF PLANT VIRUS DISEASES.

By Kenneth M. Smith. *J. & H. Churchill, Ltd.*, London, 1937, Price 21*s*.

Dr. Kenneth Smith's ' Recent Advances in the Study of Plant Virus Diseases ' is well known to plant pathologists as a good introduction to the study of the subject, and the book now under review is in no way inferior to it, and should be of considerable value both to students and research workers in temperate and tropical countries.

The book is divided into two main parts. In the first seven chapters a description, sometimes brief, sometimes in detail, of all known virus diseases is given. A large amount of information on the symptoms, the host range, the geographical distribution, the methods of transmission and the physical and chemical properties of the viruses has been summarised and put into an easily readable form. A list of the relevant literature is given at the end of each chapter. The last chapter (ch. IX) dealing with certain suspected virus diseases really belongs to this section. Chapter VIII comprises the other main part of the book and is concerned with the insect vectors of virus diseases. A concise account of the life histories, habits, morphology, food plants, &c., of the insects is given, and any peculiarities in their methods of transmitting viruses are discussed.

The author has made use of a new system of classification in which the viruses are given the generic name of one of the host plants they attack, and also a number when more than one virus attacks the host plant. For example, Sugar Cane Mosaic becomes Saccharum Virus 1, and Bunchy Top of Bananas Musa Virus 1. While such a system has obvious advantages in providing a rational basis for the classification of all known plant viruses and is also capable of indefinite expansion, it is questionable whether its adoption is altogether desirable at the present time. It involves firstly the use of a large number of new names, never a desirable characteristic of a classification; and secondly, our knowledge of plant viruses is increasing so rapidly at present that a better classification system, possibly on physical or chemical grounds, may be evolved shortly; a happening which would severely detract from the use of an otherwise valuable book.

R. E. D. B.

* * *

STEROLS AND RELATED COMPOUNDS.

By Prof. E. Friedmann, *W. Heffer & Sons Ltd.*, Cambridge, 1937, pp. 100, price 7*s*. 6*d*.

At a time when research on various aspects of biological chemistry is assuming an increasingly important rôle such books as that of Professor Friedmann are particularly welcome. This book which is an outcome of a series of lectures delivered at the Biochemical School, Cambridge, provides a general survey of the Sterols and related compounds. Special attention is paid to the relationship of the Sterols to Vitamin D, the antirachitic vitamin and Vitamin E.

When it is stated that such diverse substances as bile acids, certain heart poisons, neutral sapogenins and sex hormones, as well as Vitamins D and E, are all related to the Sterols the outstanding importance of the field of research will be realised, and Professor Friedmann's book provides a useful and interesting introduction.

* * * E. C. H.

SOUTH AFRICAN YEAR BOOK AND DIRECTORY, 1937.

Compiled and edited by the Editor, *South African Sugar Journal*, Durban, 336 pp., price 5*s*.

This is the eighth year of issue of this Year Book which is the only one of its kind. Like its predecessors it presents up-to-date and comprehensive information regarding the South African sugar industry. Accounts are given of the different sugar companies, of the work of the Experiment Station of the South African Sugar Association, and of the various organisations integral in the sugar industry. Full statistics of production for the 1936 crop are included while other statistics have been brought up-to-date. The present series constitutes a most useful historical survey of the development of the South African sugar industry and, as such, complete files of it should be kept by those particularly concerned with this industry.

SUGAR NOTES.

Compiled by the College Department of Sugar Technology.

Manufacture of Invert Syrups.—(A) *Diego G. Aurioles.* (B) *F. A. López Ferrer.*

What is called "rich inverted molasses" and "inverted syrup" is being largely produced in Cuba, the figures for 1936 being 39,959,470 U. S. gallons of the former and 12,004,522 of the latter, and this besides 113,171,107 gallons of ordinary factory exhaust molasses. Almost all of it goes to distilleries, but some of the inverted syrups, which are of a definitely better quality than the inverted molasses, appears to be finding use in sugar-consuming industries in the U. S. A., *e.g.*, in the manufacture of confectionery, of ice-cream, &c. It is also used as table syrup. Some information on its production has already been given*, and further information is now given.

In making the so-called rich inverted molasses, evaporator syrup produced in the ordinary way is placed in cylindrical tanks equipped with stirrers and steam serpentines, and concentrated sulphuric acid added at the rate of about 0.03 lb. per 100 lb. of the syrup. This mixture is heated at 200°F. (93°C.) until its pol. has fallen to between 0 and +10°V., when milk-of-lime is added until a pH of 6.0 is obtained. It is then pumped to the vacuum pan storage tanks, and evaporated to 80-85° Brix. This gives a final product resembling molasses in appearance, but bright red in colour, and having a higher viscosity.

In making the inverted syrup, the procedure is much the same, but direct contact of the acid liquor with iron is avoided; and, instead of using the evaporator syrup, raw or washed sugar is re-melted to give the syrup. This is pumped into the inverting tanks, the interior surfaces of which have been coated with acid-proof paint. HCl at about 22 Bé. is used as the hydrolyst, and the time taken may range from about 30 min. for high purity syrups to 2 hours for lower grade syrups. A temperature of about 90°C. is found suitable.

What is aimed at is the production of a syrup having a Brix of from 72 to 84°, and a pol. from +20 to +40°V. In case inversion should have proceeded too far, some of the original un-inverted syrup may be added from a smaller tank on the same platform as the other. Depending on the quality of the re-melted syrup, the colour may vary from pale amber to deep brown. It has a pleasant flavour, and is said to sell readily. Its final acidity may be between 5.5 and 6.6 pH. It may contain 25 to 30 per cent. of sucrose and 48 to 52 per cent. of reducing sugars.

Its value is calculated on the basis of its sugar content and the production is being carried out on a co-operative basis. A U. S. gallon of molasses averages 9.65 lb. of total 96° sugars, which at the price of 0.835 cents per lb., makes 8.057 cents; 20 per cent. is added to the cost of the syrup plus that of the acid which is 3.11 lbs. per 100 gallons, and the balance remaining divided among the colonos and employees. This industry is being assisted by the Government by exempting from taxation all molasses and syrups destined for alcohol production.—(*Inter. Sugar Journal*, Vol. XXXIX, No. 466, pp. 406-07, 1937).

* * *

Determining Maturity of Cane by the Hand Refractometer, *by F. Suarez Mena.*

At Central Boston the hand refractometer is giving good service in controlling the maturity of the cane sent to the mill. The extensive area of cane lands of the central is divided into four districts; each district is divided into farms, and each farm is divided into fields covering 0.3 to 0.5 caballeria each and separated from one another by fire guards 15 meters wide. On each farm there are several railroad switches and weighing stations.

A small 3-roller mill is mounted on a small railroad car which is pulled up and down the line by a gasoline track car which also furnishes power for the mill. The car is also furnished with the usual testing equipment; cylinders, hydrometer, strainers, funnels, flasks, machetes, &c.; the crew consists of a chemist, a chauffeur and a helper.

On a previous day, arrangements are made with the field staff for the sampling of specific fields. From each field five whole plants (five complete stools, except shoots less than 1 yard long) are cut and taken untopped to a designated station, where 15 such samples are assembled and await the testing car. The chemist and his assistants top and crush the cane, and determine the refractometric solids, reserving a sample of the juice (treated with 4 grms. of Horne's lead) for polarization and a check of the refractometer reading in the laboratory.

The work is begun seven weeks before the start of the crop, so as to have a sufficient number of selected fields to maintain the average milling rate, and to provide the field superintendent with data by which fields to be cut are selected on the basis of satisfactory maturity. The maturity surveys are conducted throughout the grinding season. About two weeks are necessary to complete a maturity survey of the four districts.

Extensive experience with this system has proved that the hand refractometer is the most appropriate, rapid and exact means for the determination of the solids of the juice and the maturity of the cane. A polarization in the laboratory is necessary because the refractometer indicates only when the cane has reached maturity, but does not show alterations in the amount of reducing sugars beyond that point.

A notable feature of this method is that all millable stalks in a complete stool are made the basis of sampling. All other systems involving the use of the hand refractometer are based on puncture samples of what are regarded as normal individual stalks, in disregard of the fact that thousands of stalks in the field, and even stalks of one stool, are

* *I.S.J.*, 1935, p. 392; 1936, p. 141.

at different stages of maturity and in different degrees of health; hence the selection of "normal" stalks for sampling purposes is apt to be misleading. A much better picture of the situation is obtained when every stalk in a stool is taken into account.

Note.—It is remarkable that the general adoption of this common sense method of cane sampling in the field has been so long delayed.—Ed.—(*Int. Sugar Jr.*, Vol. XXXIX, No. 467, p. 440, 1937.)

CHEMICAL NOTES.

Compiled by the College Department of Chemistry and Soil Science.

The Stimulation of Plant Growth.

The modern discovery that drugs can be administered through the plant stem in homoeopathic doses is one of considerable interest and importance. This fact was foreshadowed some twenty-five years ago by the work of H. E. and E. F. Armstrong on the leaves of the cherry laurel and the spotted Aucuba, when they showed that a considerable number of substances were able to enter the leaf and initiate changes which may be described as altering the water balance of the cell content and setting enzymic changes in motion, resulting in hydrolysis of glycosides. This work was an extension of the earlier classic experiments of Adrian Brown on the penetration of the semi-permeable cell membranes of the barley seed. The more recent observations on the ripening of fruits has shown that a vapour, proved to be ethylene, produced during ripening, is able to penetrate other partly ripe fruits, and thereby hasten the process of ripening. A new discovery involves the application of small quantities of the particular chemical substance mixed with lanolin, which is smeared on to the stem. In this way it is able to penetrate into the cells and initiate chemical changes. If the stimulus is not too vigorous the result is accelerated growth, and particularly the formation of rootlets at or near the infected part, with the very important practical consequence that the formation of roots by cuttings is much facilitated. A discovery which may be of prime importance to practical horticulture has thus been made. In order to understand the full implication of these changes, the story must be amplified considerably so as to include the growth-promoting substances, to which the name "auxin" has been given. The substances which the Armstrongs found were able to penetrate the leaf were weak acids, such as acetic and butyric acids, alcohol, ether, ethyl acetate, and many similar organic compounds, as well as certain inorganic substances; in general, substances which have a low affinity for water. It was sought to apply the term "hormone" to all those substances. On entry, such compounds produce disturbances by setting enzymes in action, and stimulating chemical change. Professor Starling, who not long before had used the word "hormone" as a chemical messenger in animal physiology, opposed its extension, but is none the less a correct designation. A hormone, as understood today, is a chemical substance which, though produced in only small quantities by the tissues, yet exercises a profound influence on the activity of some particular organ. This applies widely to animals, whereas in plants there is much less differentiation of the tissues, and it has taken a considerable time to establish their existence. The Utrecht school of plant physiologists, led by the late Professor Went and his son, has proved that growth-regulating, root-forming chemical substances are formed in the leaves and transmitted backwards: one has been isolated as a crystalline substance by the efforts of Kogl, Haagen Smit, and Erxleben, and identified as indolyl-acetic acid, termed hetero-auxin. Quite a number of related compounds have since been proved to have similar action in causing root development, curvature and bending of stem, and swelling of stems and petioles, though the original indolyl-acetic acid is perhaps as active as any substance yet tried. This acid may be regarded as a close relation of tryptophane, which is a chemical stage between protein and indole, and is one of the known products of the breaking down of plant protein. With such a clue, further progres has been rapid: naphthalene-acetic acid has proved a suitable and more accessible material for use, likewise phenyl-acetic acid and, latest of all, benzoyl oxide and benzoyl peroxide are suggested, though they have only 1/400 of the activity of hetro-auxin, which acts in a concentration of one to one thousand parts in lanolin paste. The rooting of cuttings of all sorts of plants is accelerated by the three acids mentioned, even on old thick stems; the *Journal of the Royal Horticultural Society** contains an account of the progress made, together with a number of striking illustrations depicting the root growth obtained as a result of the treatment. It is clear that, not only has the growth-regulating hormone of plants been isolated and identified, but that the chemist has provided a most efficient new tool for practical horticulture.—(*Chemistry & Industry*, Vol. LVI, No. 5, pp. 101-2, 1937.)

* December, 1936.

* * *

Control of Nematodes of Horses and Sheep.

Continuing his studies of the control of bursate nematodes, I. W. Parnell has tested the lethal effects of ten of the more common nitrogenous artificial fertilizers upon the free-living stages of sclerostomes (*Canadian J. Res.*, 15, 127, July 1937). The three nitrogenous fertilizers which lost most ammonia when mixed with faeces were found to be the most deadly—pure ammonia water has already been shown to be lethal. In general it was shown that the proportion of fertilizer to faeces necessary to effect sterilization would, in farming practice, be too high to be used if all faeces had to be treated. But in a well-built manure heap only the bottom and outer surfaces of the heap would have to be treated, for sclerostome larvae are unable to survive the heat of fermentation, associated probably with lack of oxygen and harmful products of decomposition, in the centre of a manure heap.—(*Nature*, Vol. CXL, No. 3546, p. 686, 1937.)

TREND OF THE MARKETS.

[*The notes below are based principally upon running charts of the prices of the basic grades and upon general statistical information gleaned from contemporary publications and cablegrams and are intended to be a record of movements. An attempt is made, where possible, to indicate the market outlook at the time of going to press, but no responsibility for the accuracy and subsequent truth of such observations is assumed. Unless otherwise stated the prices quoted are spot, London.*]

SUGAR.—Prices on the Home Markets have ranged as follows (c.i.f. per cwt.)

	Foreign	*Preferential*
	s. d.	*s. d.*
28th October	6 3	10 0
4th November	6 0¾	9 10½
11th November	6 2¼	9 11½
18th November	6 0	8 9¼
25th November	5 10½	9 6¾
2nd December	6 3¾	10 0¾
9th December	6 1½	10 0
(*10th December*, 1936)	4 9¾	8 6

The market has been largely dominated by the clearing up of the December account on the London terminal Exchange and, through continued liquidation, the tone has been somewhat easier and prices have been lower. Demand from refiners for actual sugar has also been rather poor. The market, however, has remained singularly immune from the somewhat disturbing developments around it.

* * *

COPRA has been a quiet market and West Indian f.m.s. is 7*s.* 6*d.* lower at £14 5*s.* c.i.f. London.—(*West India Committee Circular*, 18th November.)

* * *

LIME PRODUCTS.—*Lime Oil.*—There is little inquiry for Handpressed which is nominally unchanged at 35*s.* per lb. Spot holders of Distilled continue to ask 25*s.* *Lime Juice.*—There is no demand for Concentrated and Raw is quiet and unchanged at 1*s.* 9*d.* to 2*s.* 3*d.*—(*West India Committee Circular*, 18th November.)

* * *

COFFEE.—The market has been dominated by events in Brazil where it was announced early in November that the export tax on coffee would be reduced by 75 per cent. and that the Rio and Santos market would be closed until further notice. The immediate reaction has been a fall in prices with Superior Santos quoted at 34*s.* 9*d.* and No. 7 Rio at 27*s.* per cwt.

* * *

COCOA.—Because of the hold-up of the Accra crop by the natives, the lack of offerings from Brazil and a better feeling generally, prices firmed up somewhat during the latter part of last month. Any improvement or probabilities of improvement in general conditions will immediately have its effect on cocoa, but there is a chance that because of the hold-up on the Coast, a temporary technical squeeze might be created.

Accra cocoa is generally quoted at 27*s.* 6*d.* and locally Plantation is offered at $7 per fanega.—(*By Courtesy of the Cocoa Planters' Association of Trinidad, Ltd.*)

RUBBER.—Quotations for Plantation Sheet have ranged as follows:—

	Pence per lb.
27th October	.... 7 1-4
3rd November	.... 7 5-16
10th November	 7
17th November	 7
24th November	.... 7 1-16
1st December	.... 7 5-16
8th December	.... 7 5-16
(*11th December*, 1936)	.... 8 5-8

The market has generally been quieter and easier, the weakness in Wall Street, poor demand, disappointment over President Roosevelt's message to Congress and the general growth of stocks in the United Kingdom being the principal factors involved. On 23rd November the price declined to 6 13-16*d.*, the lowest record for some time, but since that date the market has rallied and is steadier. At the time of writing the meeting of the International Rubber Regulation Committee had not been held but it was hoped that the Committee would reduce the exportable quota percentage to 70. American consumption for October at 38,707 tons was somewhat disappointing.

* * *

COTTON.—The following are the official spot prices in pence per lb. of the Liverpool Cotton Association.

	American. Mid.	*Egyptian F.G.F. Sakel.*
29th October	4.83	7.77
5th November	4.55	7.22
12th November	4.63	7.38
19th November	4.55	7.17
26th November	4.64	—
3rd December	4.65	—
10th December	4.70	—
(*11th December*, 1936)	6.93	10.73

The market for American raw cotton has generally been quiet with prices showing a slight sagging tendency. Considerable interest has been shown in the fourth official estimate of the American cotton crop which at 18,243,000 bales is a record. Good business has been done in West Indian Sea Island cotton at 19*d.* per lb. for medium stapled cotton and 23*d.* for superfine. Stained 8*d.* to 11*d.*

* * *

BANANAS.—A fairly good demand but prices are £2 lower at £17 5*s.* per ton delivered London and £17 nearest station Provinces. Brazilians are slow at £13 delivered London and £14 delivered Provinces.—(*West India Committee Circular*, 18th November.)

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